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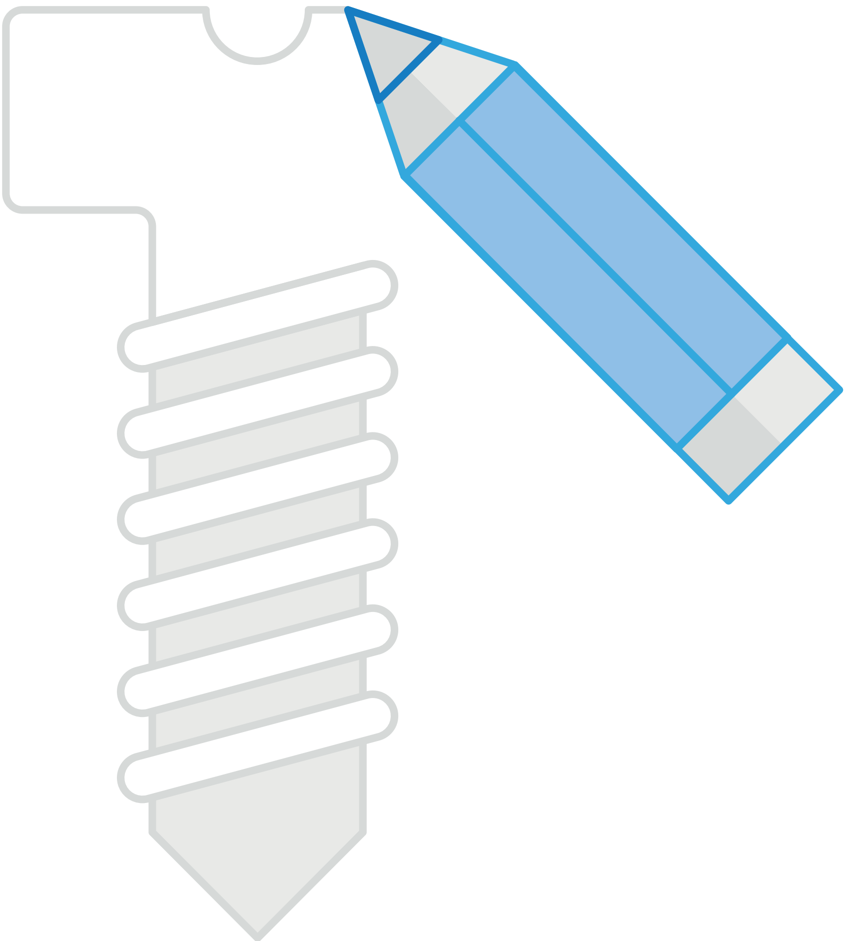

The notion of "appearance" in coatings

White Paper

The notion of 'apperance' in coatings

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ASSEMBLY
TECHNOLOGY
EXPERT

THE NOTION OF "APPEARANCE" IN COATINGS

Introduction

Too glossy, not black enough... fastening elements must have certain characteristics, which have more to do with Design than with their functional characteristics. This requirement is ever more frequently added to traditional characteristics, such as resistance to corrosion, mechanical resistance, and dimensional requirements.

However, the solution cannot be limited to just one color, or a level of gloss ... it must also take into account the primary function of the coatings. Resistance to corrosion, dimensional compatibility, preserving the strength of the base materials; these are the principal functions.

The 'design' function

Several functions can be involved in coatings, firstly the esthetic element; the brilliance, the color, and the roughness, which will allow the fastening element either to be seen, or to blend in with the assembly.

THE NOTION OF "APPEARANCE" IN COATINGS

Glossy, satin and matte coatings

For ages, the esthetic coatings of choice have been nickel-plating and chrome-plating, which are deposited onto steel and copper-based metals. The iridescence and brilliance allow for coatings that are often compatible with industries that have little to do with mechanics, such as interior design, health management, luggage... and which are used on screws, rivets, and special fasteners.

These coatings are relatively costly as the price of the materials based on Ni and Cr are high; however, the vat based electrolytic process allows one to moderate the manufacturing costs. To facilitate the adherence of the coatings, a coating of copper plating can sometimes be done on the nickel plating.

Nickel is a silver-white metal with yellow highlights which has a polished shine. It is a malleable metal, which, thanks to its resistance to oxidation and corrosion, is used in the composition of coins, but also several highly resistant metal alloys.

Nickel plating can also give a brilliant look to treated parts and provide protection from oxidation.

Like chrome plating, nickel plating requires a preliminary cleaning and degreasing phase followed by stripping. The part is then polished, particularly if the final appearance and esthetics are important.

There are two procedures for nickel plating: nickel electroplating and chemical nickel plating.

Nickel electroplating is a galvanoplasty application that consists of the electrolytic deposit of aqueous solutions. It can be used on different media:

- Steel
- Stainless steel
- Copper/brass
- Aluminium
- Magnesium
- Zamak
- Titanium

Chemical nickel plating('electroless') consists of depositing nickel (bonded to phosphorus or boron) without a source of current. The object being coated is submerged in a nickel bath. This method results in an increased hardness and better resistance over time and with exposure to friction than does nickel electroplating.

Certain people suffer from nickel contact skin allergies. This is why one more often finds chrome-plated parts rather than nickel-plated parts in the vast majority of watches.

Mechanical polishing of stainless steel and aluminum

Mechanical polishing allows one to obtain extremely varied surface states from practically any point of origin. Mirrored, glossy, matte, satin, brushed... Mechanical polishing can have a decorative or technical aim, whether in an industrial, commercial, or consumer sector, or for any other entirely different use. For the mechanical polishing of stainless steel, different abrasives are used, from the coarsest to the finest, according to the result sought.

Mechanical polishing also implies the use of different tools according to the profile of the part to be polished. Depending on your objectives – esthetic appearance, decontamination, protection and reinforcing against oxidation – we can combine mechanical polishing with a chemical treatment such as **electrolytic polishing**. In this way we are able to meet every request relating to mirrored polish, glazing, brushing for any grain, satin-finishing, to a specific degree of roughness, weld shaving, deburring...

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Micro-Peening

Micro-Peening is a procedure consisting of shooting glass or ceramic beads at a surface in order to improve the overall finish of the surface or to eliminate contaminants from it.

It can be used to reduce the tooling marks in a compound, but also to smooth the surface in order to obtain a more regular, uniform finish. This procedure is particularly beneficial when various manufactuing methods have been used to produce a compound or product, each having left the surface in a different state. Micro-Peening can also be used to return a tarnished or patina finish to a clean, new surface.

Advantages and Characteristics

- Improves surface finish after manufacture
- Can be used to decontaminate surfaces
- Option of glass or ceramic beads
- Smooths the surface after prestress shot blasting

Zinc plating and Zinc electroplating

The most prevalent in the field of fixing are zinc and zinc nickel, where the electroplating is often supplemented by a passivation and/or topcoat, which gives the coating friction properties, corrosion resistance, and of course its appearance.

Naturally, zinc and zinc-nickel without passivation (or with colorless passivation) are respectively, glossy silver and matte gray.

If we add acid or alkaline passivation methods, we have iridescence of different colors depending on the formulation.

However, two larger categories of passivation are used, the first of which is the hexavalent group, which generates greenish, yellow, black, and white colorations. The latter are more and more limited due to the fact that they contain Chromium-6 and that this element is covered by the RoH and Reach prohibitive directives.

Substitution passivations are trivalent passivations, which present iridescences with less notable color: green, yellow, and gray.

These coatings are sometimes supplemented by a top coat, a black organic film that increases corrosion resistance (approx. 50 to 150 h with a neutral salt spray) and which can have a black satin, very esthetic, appearance.

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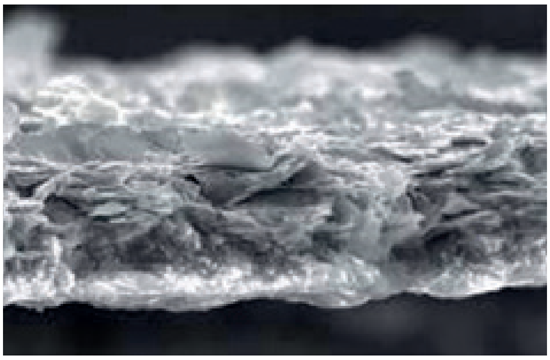
Black and gray coatings

Zinc flake coatings

Zinc lamella or flake coatings are a dry film made up of numerous small flakes, where the basic principle is to protect a multitude of components from corrosion. Thanks to the "sacrificial effect" of zinc, which is less noble than steel, it offers active protection against environmental influences: this form of corrosion protection is called sacrificial cathodic protection. Most of the time, zinc flake coatings are made up of a combination of zinc and aluminum lamella (in compliance with the standards DIN ESO 10683 or DIN EN 13858), included in an inorganic matrix. See the microscopic cross section:



Even extremely thin layers - a system typically consists of an underlayer and a finish of 8 to 12 µm – allow for a protective effect against corrosion of the base metal for up to 1 000 hours (red rust) in compliance with the DIN EN ISO 9227 standard.

The matte gray color will be obtained in the case of standard products with or without a finishing coat, because this is the base color of the under-layer of zinc and aluminum flakes. This color perfectly matches hot-galvanized and stainless steel parts, see electrolytically galvanized parts. The number of layers does not affect the tint and the lubrication system that can be included in the two layers or just in one, nor does it affect the gray color obtained.

Note the need during design itself to perform particularly fine layers to ensure the fit of threaded parts.

The process of applying the coatings does not produce hydrogen and therefore allows you to reduce the risks of it becoming brittle. This is why zinc flake coatings are particularly well adapted to high strength classes. Thanks to their high performance and thin gauge, zinc flake methods have largely taken over in the field of screws and fastening in the automotive industry: one screw in two of the leading manufacturers is coated with zinc flake.

The finishes complement the characteristics of the sub-layer and above all, they can also be used to color treat parts, knowing that the standard colors are silver and black. Thanks to their versatile properties, they can be used in a wide variety of applications. Depending on the expected use of the treated parts, you can choose organic or inorganic finishes, which can be deposited on the zinc flake, or electroplating.

The zinc flake also exists in a black version, the finish coat called top coat will in this case have the double function of determining the coefficient of friction and the color. Colorants are introduced into the finishing layer, which can be black, although other colors are possible.

This color in general remains matte black, but new formulas are being developed to give them a satin finish. The best known are Geoblack®, Deltaprotekt®, Zintek® and Magni®.

Note that from a chemical point of view, the introduction of organic and organo-mineral colorants will reduce the corrosion resistance of the layer concerned, so work is being done to develop two product lines, the matte black coating standard that reaches a performance level equivalent to gray, and coatings with a deeper black somewhat satin finish for which corrosion resistance will be slightly lower. The latter will have more esthetic applications and can be used in association with the new coatings (satin nickel plating, black zinc nickel...) and brilliant composite materials.

Anti-friction coatings

Tribological dry coating is a system solution for mechanically loaded fastening elements and components such as screws, nuts and washers. These are thin coatings, by non-electrolytic means, that have lubricating properties and provide added protection against corrosion. The coating consists of a composition containing fluorinated polymers and organic particles of a solid lubricant; all of which are dispersed in mixtures of synthetic resins, along with carefully selected solvents. This coating consists of a thin smooth layer that allows surface imperfections to be corrected, thus reducing friction even in high constraints and extreme working conditions.
The synthetic resin, for its part, provides added protection against corrosion. The application of the coating is done manually by means of pulverizer pistols or in a machine with automatic bulk passage in rotating drums. The pulverized layer is then polymerized in the oven, where it acquires exceptional adhesive qualities as well as protection from corrosion. The thickness of the layer varies according to specifications and requirements, from 5 to 12 µm.

Key Features:

- Excellent low dispersion friction values as a basis for each screw fastener assembly
- Dry and environmentally friendly coating with a remarkable ease of use
- High security of assembly during manufacture and maintenance
- Economical assembly/disassembly, with an overall reduction of up to 30% of process costs.

Baking temperature
When selecting the material, it is necessary to note that a large number of anti-friction coatings cure at temperatures between 160 and 250°C. This is especially true for highly wear-resistant anti-friction coatings. The components also reach these temperatures, which is why they need to be sufficiently resistant. The curing time is between 15 and approx. 60 minutes, depending on the temperature. If materials are not temperature-resistant, there is the option of using air-drying or moisture-curing anti-friction coatings.

Corrosion protection
It is possible to increase the corrosion protection accordingly, for example, by using a preliminary phosphate layer as a substrate or by electrogalvanizing.

Temperature stability
The upper and lower service temperature of an anti-friction coating is determined on the basis of the binder and the solid lubricant. The temperature stability of the anti-friction coating depends on its chemical composition (binder, solid lubricants).

Tribological coating with TopCoat in black/silver

Sherardizing

Invented at the beginning of the century by Sherard Cowper Coles, Sherardizing is an anticorrosion thermo-**chemical** process of diffusion and penetration of zinc into steel. Sherardizing allows you to obtain an iron-zinc alloy-type coating by heating the parts (380 to 450°C) in the presence of zinc powder and an inert material. The procedure unfolds in solid phase in a closed unit moving through a slow rotation.

Several post-treatments can be done: passivation without chromium-6, gray in color. Non-alloyed carbon steel, HR steel, sintered material, iron, and cast iron are very suitable for Sherardizing.

Zinc thermal diffusion is another zinc diffusion coating on ferrous products (ISO 17668).

The parts to be treated only require pre-treatment if there are impurities (e.g. mill scale or rust) present. Abrasive blasting, for example, removes these impurities. If the products are uncoated, no pre-treatment is necessary. The metal products are heated with a zinc powder mixture, consisting of zinc dust and additives, in slowly rotating vessels at temperatures between 280 and 390°C. During this process, zinc diffuses into the base material. This produces a zinc micro-alloy with a coating thickness of 4 μm to 25 μm, depending on requirements.

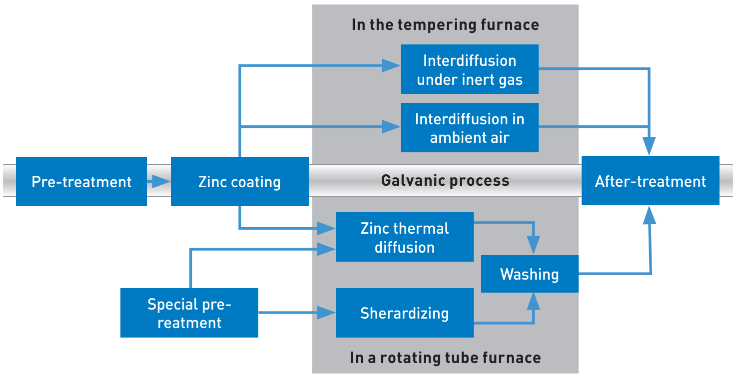
Advantages:
- Protects against damage even during forming processes
- Uniform coating thickness even with complex geometries
- Very good adhesion and temperature resistance
- No hydrogen embrittlement

Thermal blackening

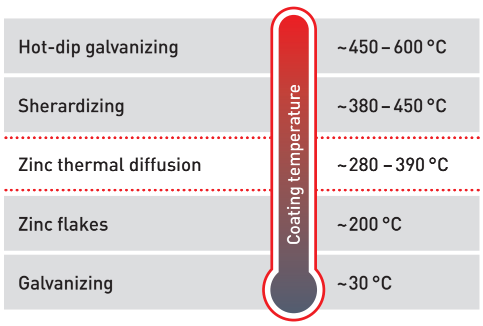
This surface layer automatically appears during the processes of hardening and tempering high strength steel parts. The parts are generally hardened in a protective atmosphere furnace. They remain untouched. During the following tempering, done without protective atmosphere, they are given a coat of black to dark gray oxide that is extremely adherent.

The resistance to corrosion is moderate. It is strengthened by means of an oil film. Oiling is carried out by immersion in aqueous emulsions of oil and is followed by a centrifuging operation. Thus, the elements of assembly benefit from a minimal protection in their packaging during transport and storage.

Sometimes, certain screws or bolts are over oiled. This can lead to assembly or guidance problems in installations with automated assembly.



Simplified zinc diffusion process chain



Burnishing

This post-treatment devoted to steel screws of all types of resistance and other steel products is often confused with thermal blackening. In general, burnishing is done hot. Once cleaned, the untouched steel parts are plunged into alkaline, oxidizing and aqueous solutions. In this bath, heated to a temperature from 135 to 145°C, a layer of black iron oxide forms. Its thickness varies between 0.5 and 2 mm. It is a conductor.

The burnishing procedure can be divided into several steps: these are performed either in vessels or in fully automated drum devices. As with thermal blackening, burnished steel parts have a very limited resistance to corrosion. To obtain better results, an oil-based finishing coat is always applied, based on oil, grease, or wax.

Burnished parts are well suited to interior applications. If used out of doors, they must be dried and oiled or waxed after they become wet. Otherwise, light traces of rust can appear immediately. Example: cleaning hunting weapons.

Black oxidation of stainless steel (also at times called burnishing)

Stainless steel surfaces can be readily blackened by immersion in a bath of molten sodium dichromate. This practice, which is relatively simple to implement and to use, is largely employed in the automobile industry - to burnish stainless steel parts such as windshield wipers - but also by manufacturers of solar panels.

The treatment is done in an oxidizing environment. The surface of the ferrous product is covered by a thin layer oxide that is blue in color. This thin layer adheres to the surface. This procedure, applicable to all types of stainless steel, causes the formation of a very thin film of black oxide and smoothens the steel's surface. This film is normally matte but can be rendered brilliant by the application of oils or waxes. It is not subject to ageing and does not lose its color during use.

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Colored coatings

Anodization on aluminum and titanium

Anodization consists in producing layers of metallic oxide, which are thicker, on aluminum parts (thickness of about 20 mm). These coatings are extremely porous. They can be stained and/or absorb anti-corrosive substances.

At the time of the Anodization operation, we create, inside the aluminum, in the dipping baths, a protective layer that is quite thick, depending on the [planned] location of exposure of the aluminum treated, interior or exterior...

In the pores of this protective layer, we can choose whether or not to deposit, by chemical or electrolytic means, any type of colorant. In cases where no colorants are used, the tint is said to be natural. Moreover, we can also obtain, through chemical, electrolytic and even mechanical industrial processes, different appearances for the treated parts: polished, brushed, brilliant, glossy satin, matte satin.

Once the appearance and color are done, the protective anodization layer is sealed to make it inert with respect to the external environment.

The principal colors obtained are natural tints, gold, bronze, blue, gray, green, black, red, orange, violet, and others for interior and exterior use.

Titanium behaves in a manner that is similar to aluminum and allows the same possibilities in terms of anodization and color.

Aluminum has the capability of combining a very high level of resistance to corrosion and a varied esthetic potential.

Paint

Whatever the procedure used, depositing paint obviously allows you to obtain partly or entirely colored fastening elements.

Two families of process are used, powder paint (epoxy) and thermal coating. These coatings can be applied to the head of screws or on the entire part, but it is of course not advisable to apply it to metal threads as the thickness of the coating is not compatible with the function of screw tightening.

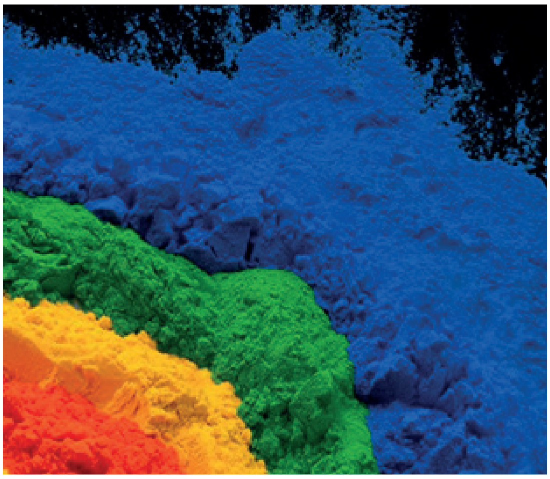
In the form of a colored powder (EPOXY or POLYESTER), this paint is applied in one or two coats according to the required performance of the process. Baking between 180° and 200°C enables the polymerization of the paint, and creates a tight and impervious film.

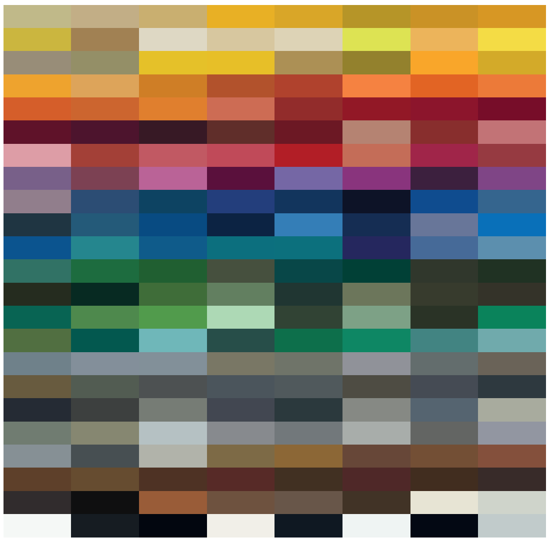
Thermal coating offers protection to your parts which is both attractive and resistant.

- Excellent mechanical performance
- Weather resistant
- Protection for heavy duty parts
- Anti-corrosion protection
- Excellent chemical stability
- Good electrical insulation

The color definition uses RAL codes because there is a very large range of possibilities, due to the particular application.

RAL colors are numbered using 4 digits. In the beginning there were 40 colors but there are now over 200 today. Example: RAL 9020 or RAL 3001. These are the two most common colors!





Plastics

Plastic fasteners (nylon or other polyamide) also have the ability to embed color additives in their composition that will have a color identical to the paint. Their color definition can also be made by a RAL code.

The coloring can be achieved by caps which are inserted into the hollow cavity of a screw to hide the screw head with a color identical to the assembled product.

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Summary

There are many possible solutions and base materials, so the geometric tolerance and esthetic complexity desired will need to be taken into account by the designer in order to find the best technical and economic solution.

If you need further assistance or have special finish requirements, please check out our contact page at **www.bossard.com** and talk to your nearest Bossard customer service representative.